



# Together, We Discover

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## **STRUCTURES AND MATERIALS RESEARCH AND TECHNOLOGY**

Artemis Technology and Advanced Manufacturing

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NASA Langley Research Center

LEAD Peninsula Technology and Manufacturing Day  
Hampton, VA    February 2, 2022

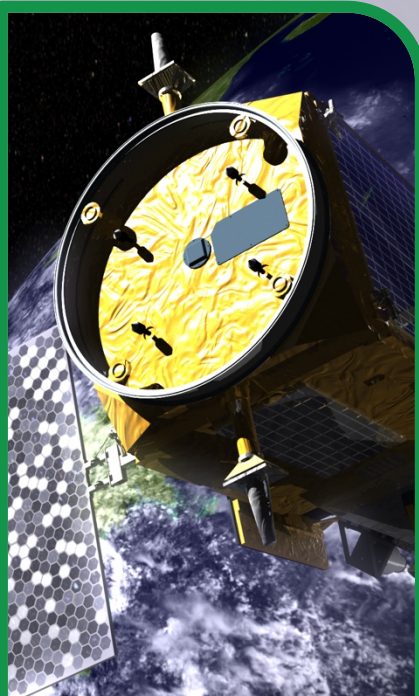




# Our Role in NASA

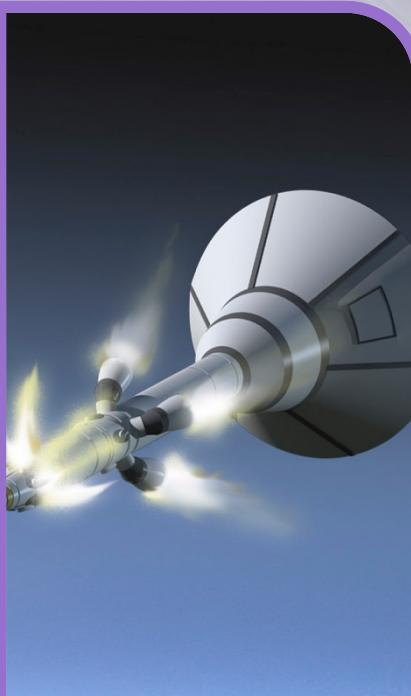
## Langley Research Center

### SCIENCE



Studying Earth and  
worlds beyond

### SPACE EXPLORATION



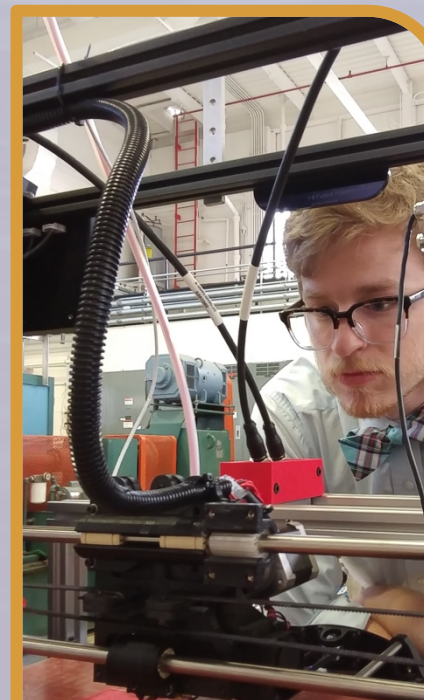
Tools to take us  
from Moon to Mars

### AERONAUTICS



Cleaner, faster,  
safer air transport

### TRANSFORMATION



Future of Langley's  
work and workforce

### STEM ENGAGEMENT



A new generation  
of explorers



# Reach to Deep Space

## Build

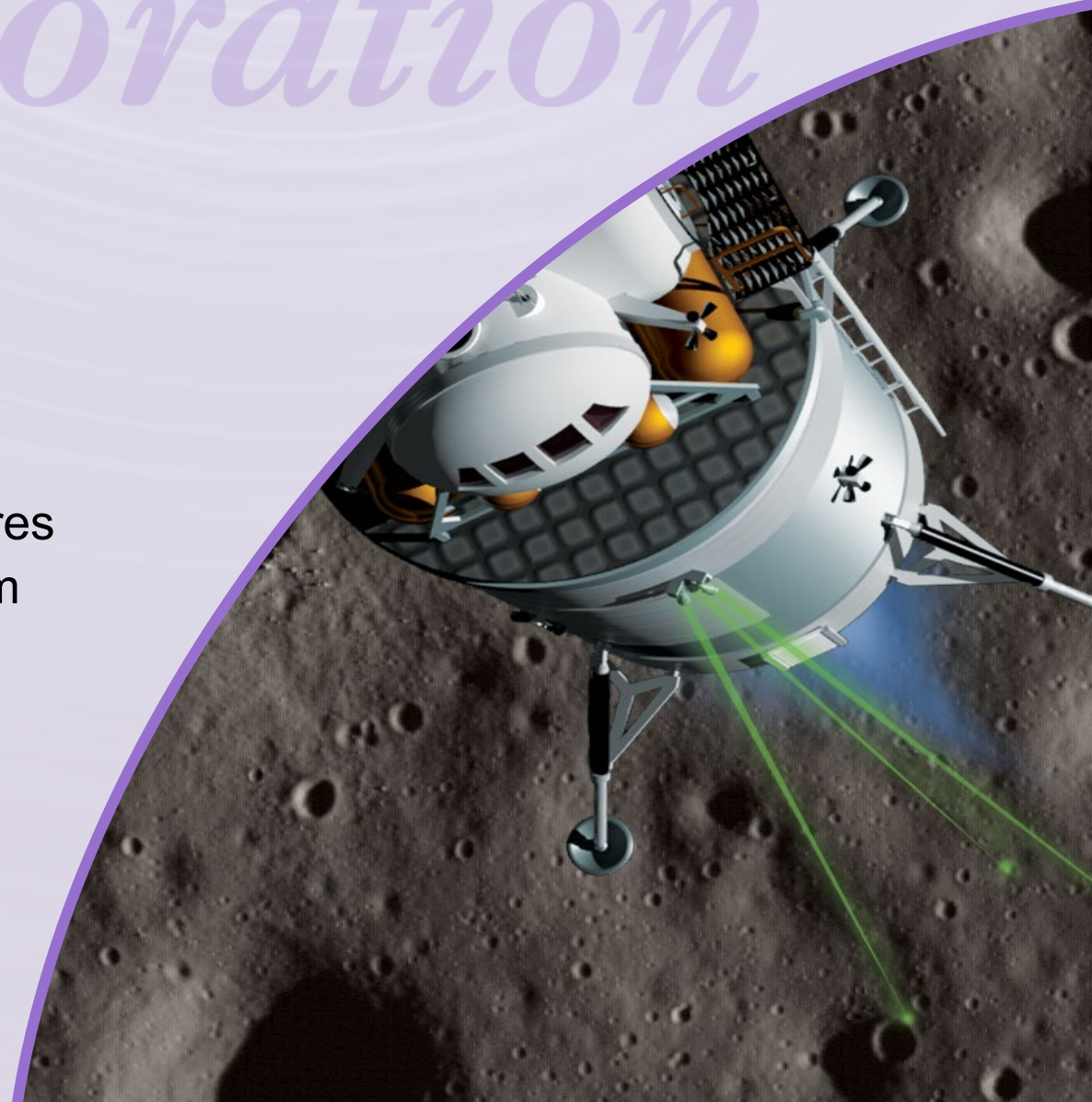
Create building blocks of Moon and Mars exploration

## Fly

Envision and develop missions, vehicles and structures needed for tomorrow's exploration of the solar system

## Land

Enable people and cargo to arrive safely on other worlds through mastery of entry, descent and landing





# Turning INSIGHT and INVENTION into IMPACT

## Insight

Leverage external/internal research to discover, understand and predict fundamental physics to enable ourselves and others to understand the technical challenges that are barriers to advancing the future in aerospace

## Invention

Collaborate to conceive and develop technology solutions to make our desired future real and/or an even better future possible

## Impact

Partner to infuse technology solutions that demonstrate system-level benefits that enable the Agency's missions and solve the Nation's aerospace challenges







# Innovation From Moon to Mars



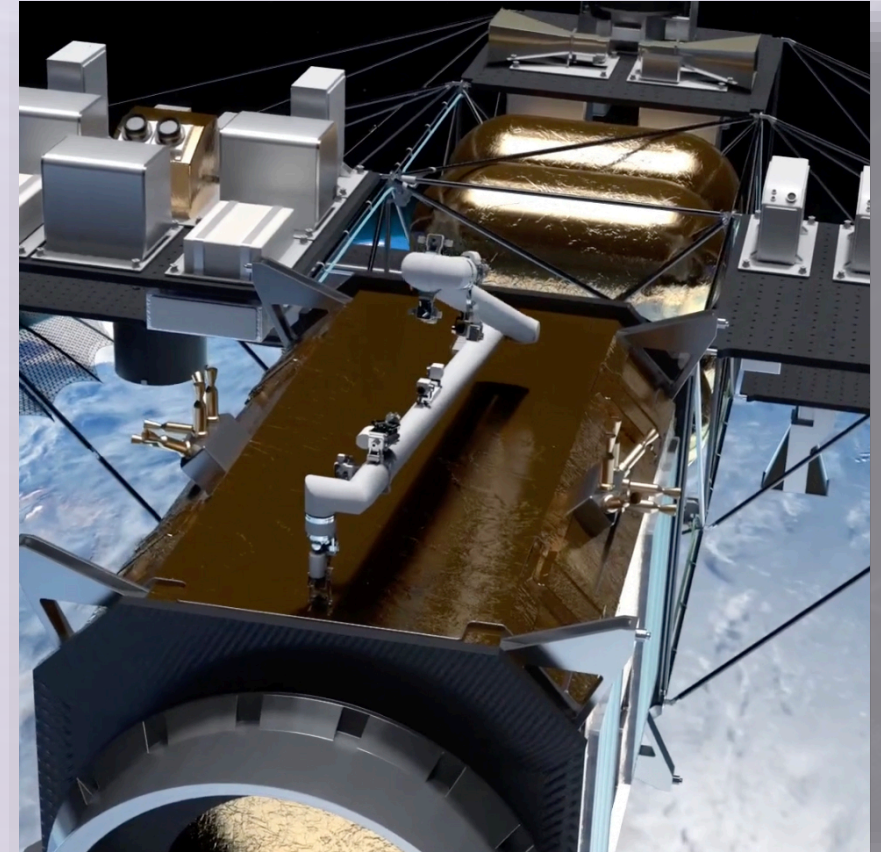
Langley advances science, space technology and exploration through enabling technologies, strategic partnerships and collaborations.



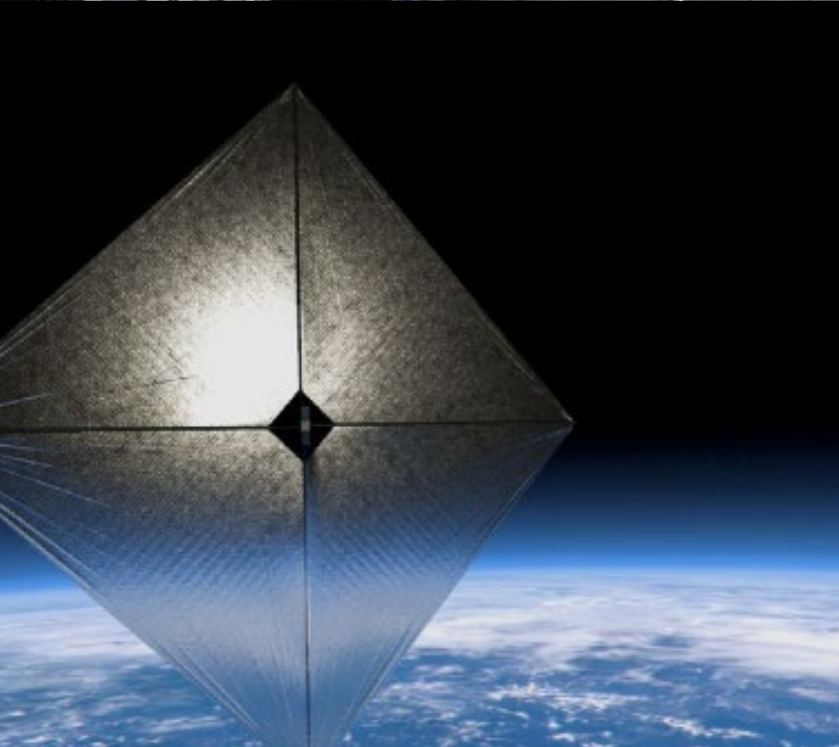


# Autonomous In-space Assembly

Langley develops concepts for safe and reliable autonomous systems to supplement human operations, including mechanisms that can maneuver, assemble and service structures.







## REPRESENTATIVE PROJECTS

- TALISMAN – Tendon-Actuated Lightweight In-Space MANipulator
- Lightweight Surface Manipulator System – robotic manipulator that can lift and precisely position equipment either on the lunar and/or Martian surface
- Assemblers – A modular and reconfigurable manipulation system for autonomous in-space assembly
- SPIDER – Enables satellites to self-assemble in orbit. Langley is developing the robotic assembly interfaces
- SAMURAI – Strut Assembly, Manufacturing, Utility & Robotic Aid, used to hand off struts to NINJAR
- NINJAR – NASA Intelligent Jigging Assembly Robot precisely positions truss members for welding after hand-off from manipulator (TALISMAN)
- Deployable Composite Booms (DCB) - enable reliable deployable structural systems for low-cost, small volume, rideshare-class spacecraft
- Advanced Composite Solar Sail System (ACS3) – demonstrates use of composites in its lightweight booms that deploy from a CubeSat



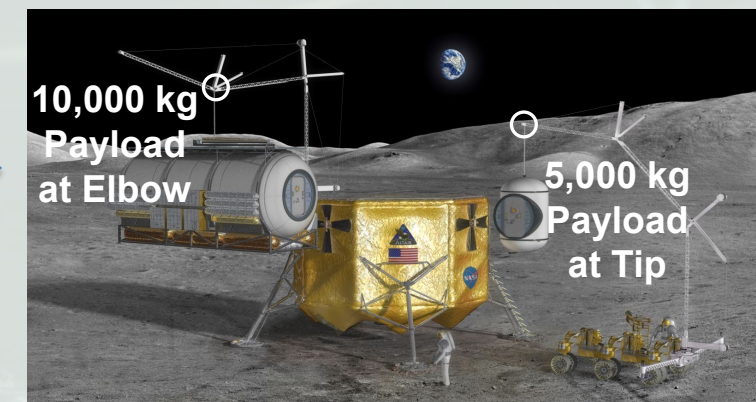
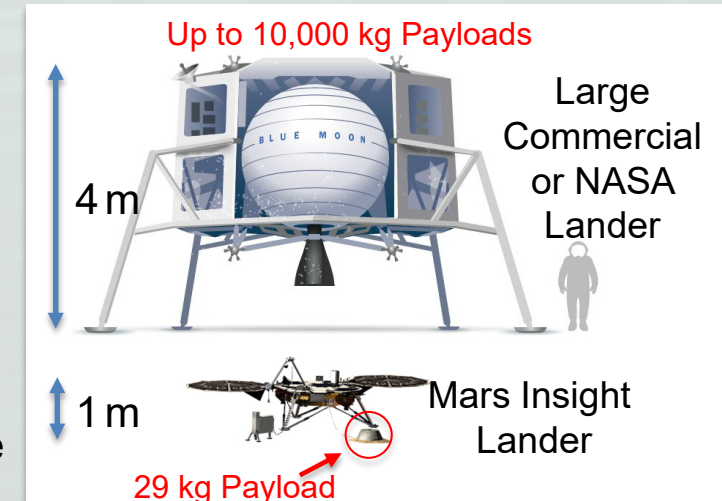
# Lightweight Surface Manipulation System (LSMS)

**The Problem:** NASA and commercial landers require a robust approach to offloading and maneuvering payloads in a wide range of masses, sizes, and shapes.

**State of the Art:** Planetary-surface serial manipulators do not scale to heavy payloads.

- Payload mass and size, reach required, and height and size of lander, are all significantly greater for large commercial and NASA landers.

**The Solution:** Lightweight, scalable and versatile, long-reach manipulator that combines the structural efficiency and robustness of commercial cranes, with the enhanced dexterity and multi-functionality of deployable robotic arm.





# Exploration Architecture and Systems Analysis

For over 30 years, Langley has provided system analysis and architecture experience to human and robotic spaceflight programs across NASA's human exploration, science and space technology portfolios.







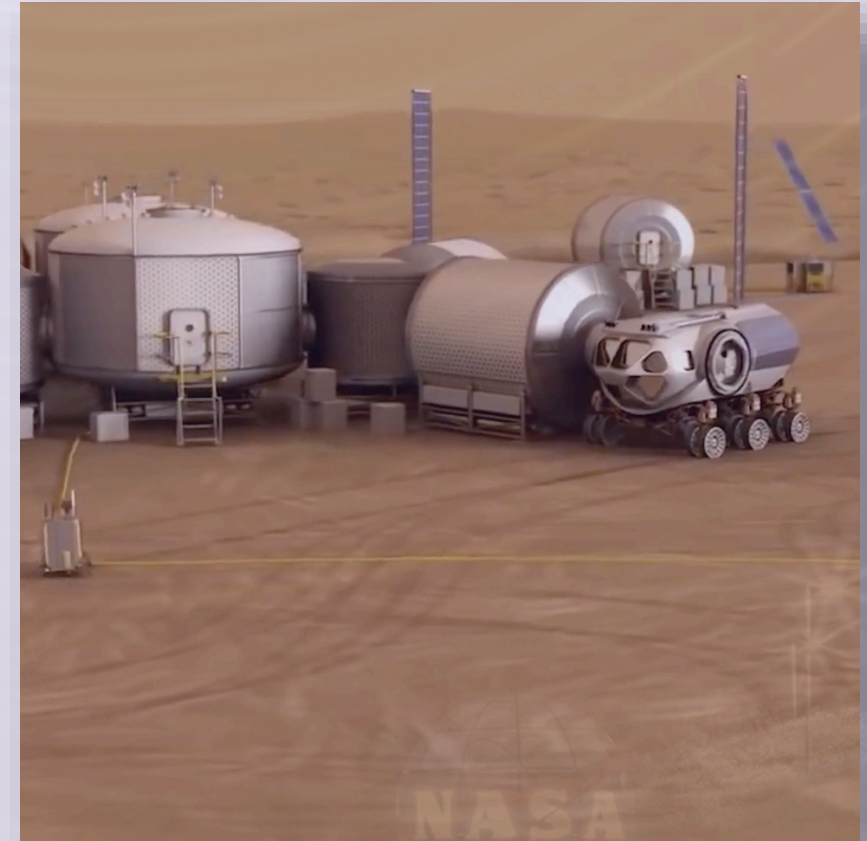
COLLABORATIONS WITH LANGLEY'S EXPLORATION ARCHITECTURE TEAM ENABLES CUSTOMERS TO MAKE BETTER INFORMED DECISIONS THROUGH ANALYSIS PRODUCTS SUCH AS:

- Mission architectures
- Systems concept designs
- System and technology trades
- Campaign analyses
- Life-cycle cost and risk analyses
- Development of tools supporting technical, programmatic and budgetary analyses

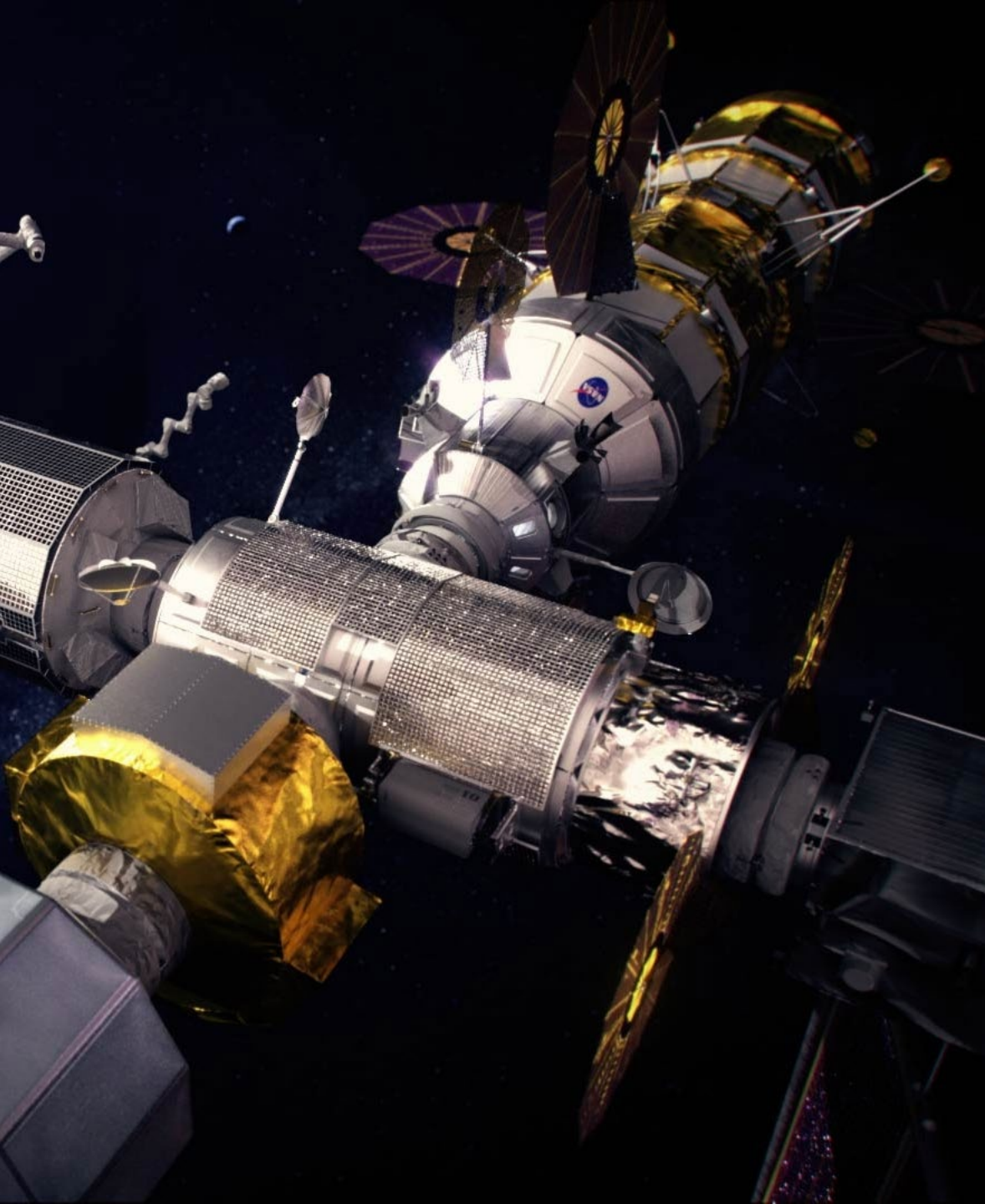


# Space Habitation / Radiation Protection/ Gateway

Langley's Space Habitation Systems and Radiation Protection team focuses on the development of in-space habitation systems and radiation protection.







# SPACE HABITATION SYSTEMS

## Habitation and Systems Concepts:

- Supporting NASA collaborations under NextSTEP, HLS, and Gateway such as:
  - Radiation environment modeling and mitigation approaches
  - Lightweight structures and materials analysis and testing
- Analysis of habitation and radiation requirements, interfaces, and demonstration objectives

## Alternative Materials for Habitat Structures:

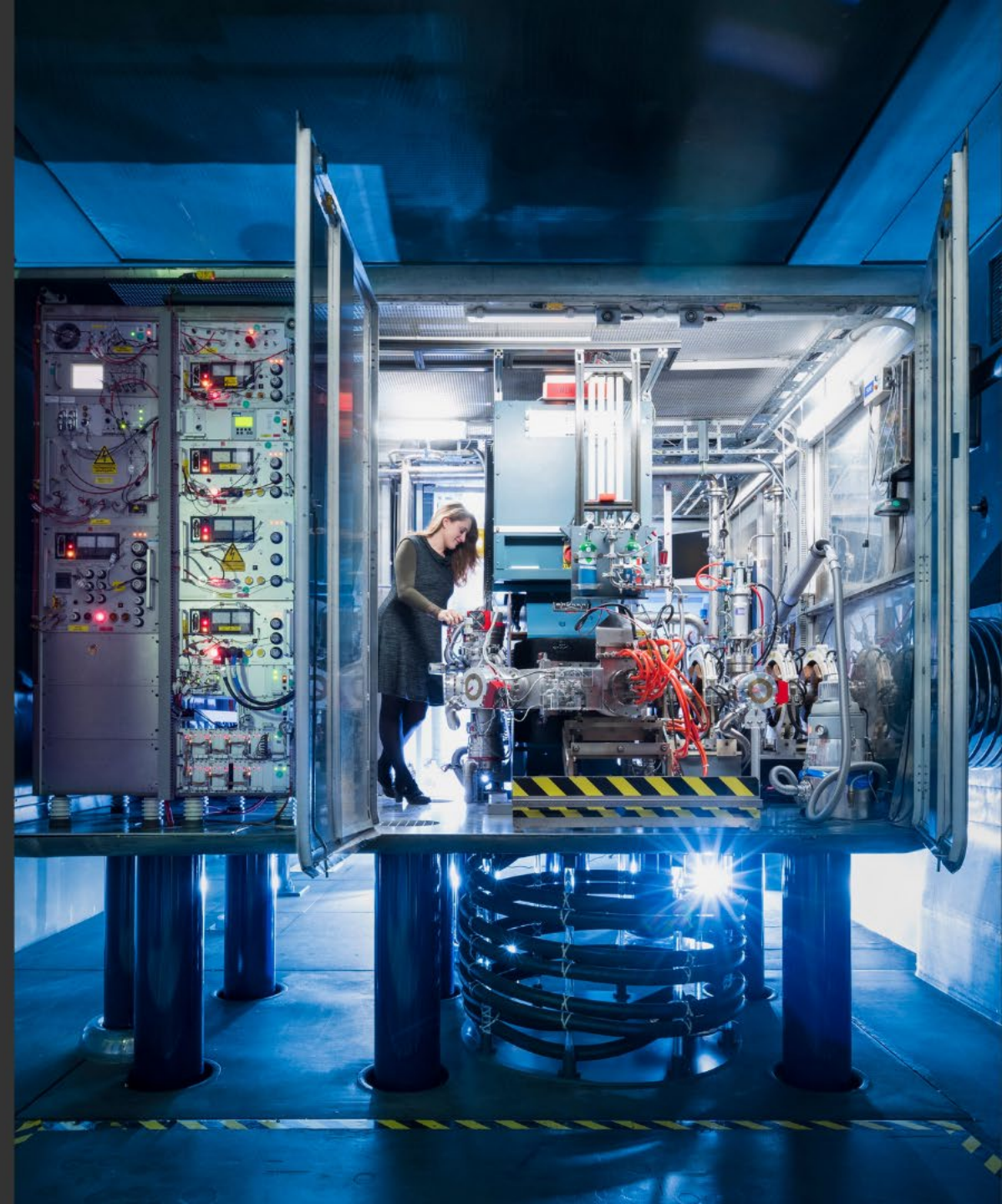
- Assessing use and certification of composites and soft goods for habitats
- Advancing structural technologies for habitat mass and risk reduction



## RADIATION PROTECTION / GATEWAY

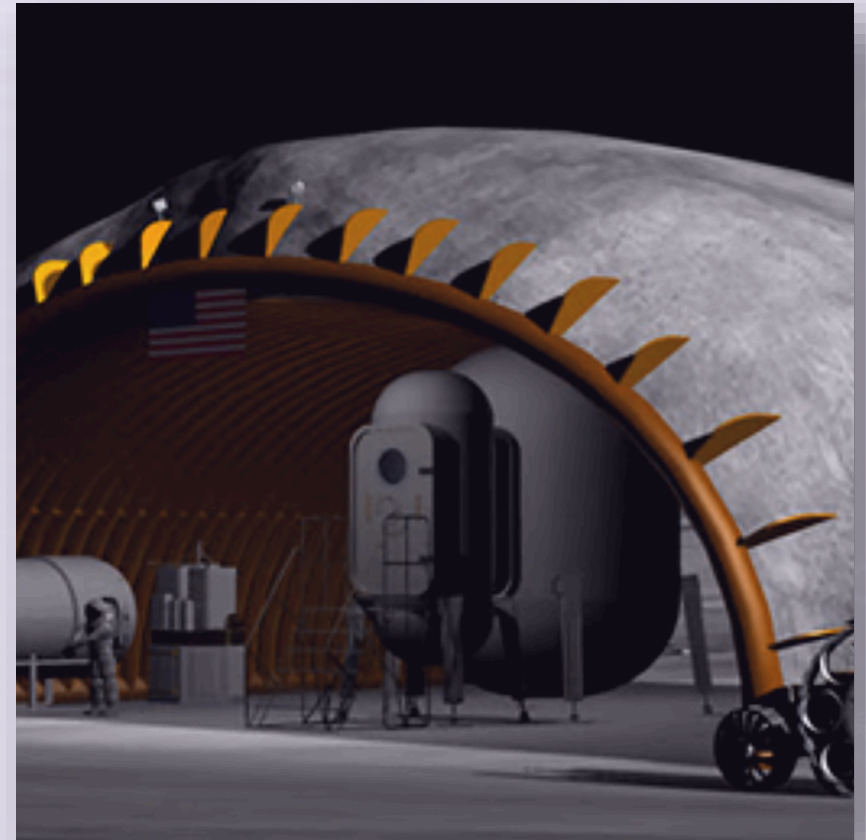
Langley works on an array of projects designed to help limit human exposure to radiation during space exploration including:

- Advanced technologies, analysis methods, and sensors analysis for radiation mitigation approaches
- Modeling and analysis to better understand crew doses and promote safety on future missions
- The development and testing of wearable radiation protection concepts for in-space use
- Use of soft goods, composites, and advanced materials for in-space habitation systems
- Supports NASA Headquarters in the requirements, design, testing and development of space habitats

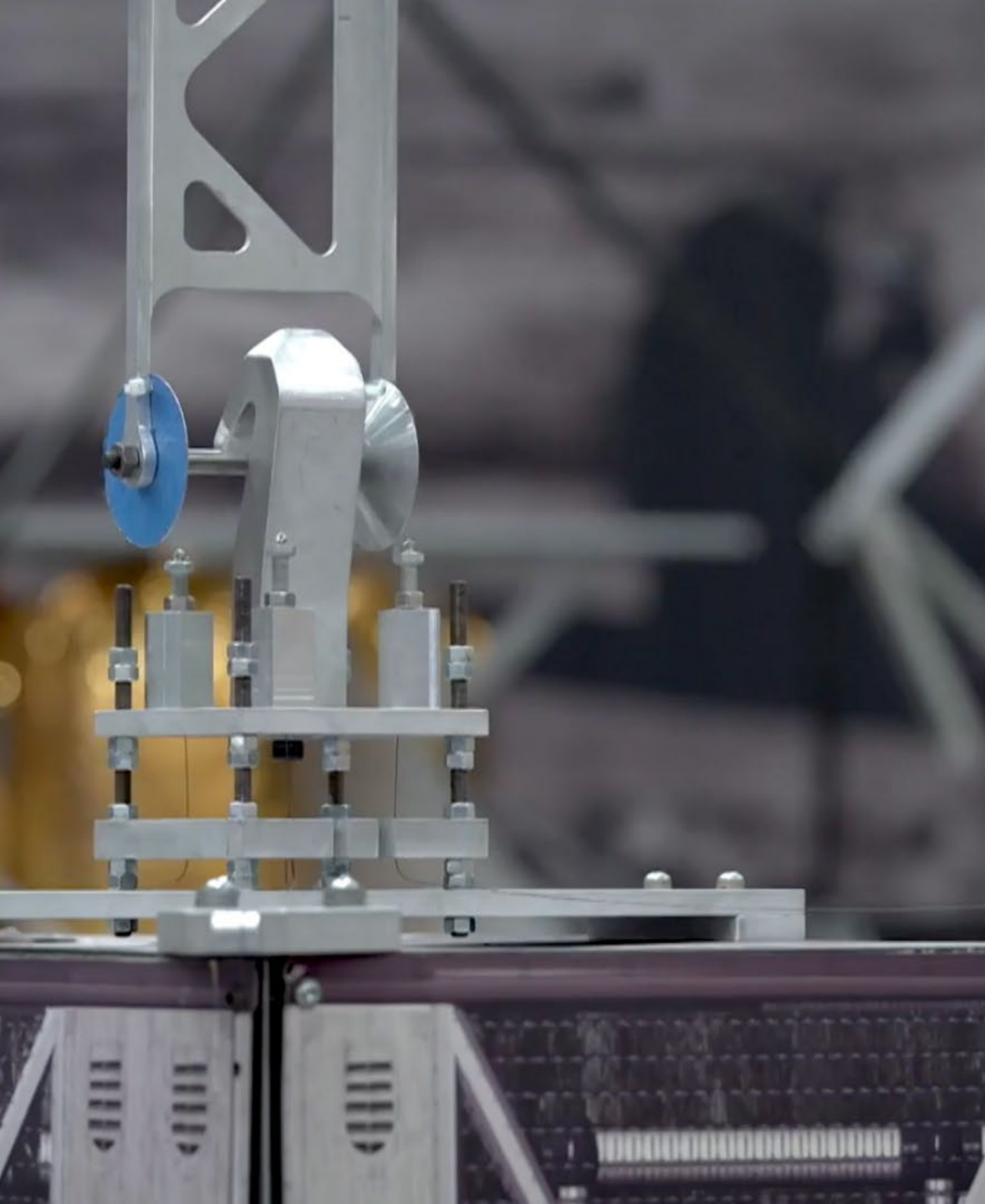


# Structures and Materials, Advanced Manufacturing

Langley focuses on advancing state-of-the-art lightweight structures, materials and manufacturing methods, playing a vital role in advanced and additive manufacturing of metals and composites, high temperature composites and ceramics, hybrid metal systems, and carbon and boron nitride nanotubes.



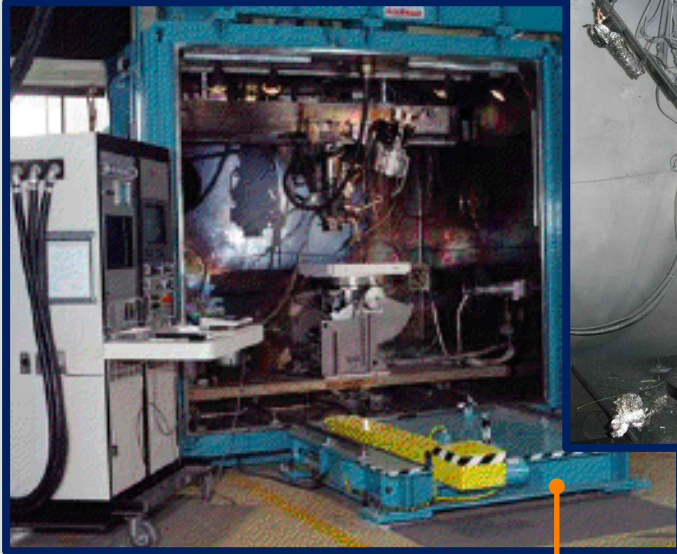




## CAPABILITIES

- Material synthesis, coatings, and treatments
- Process development, assessment and certification
- Advanced metal alloys, metal matrix composites, and composite structure bonding and joining
- Advanced and additive manufacturing of metals and composites, high temperature composites and ceramics, hybrid metal systems, and carbon and boron nitride nanotubes
- Recyclable, repurposeable material systems
- Inflatable and hybrid structures
- Advanced modeling, analysis and NDE tools

# Process Development



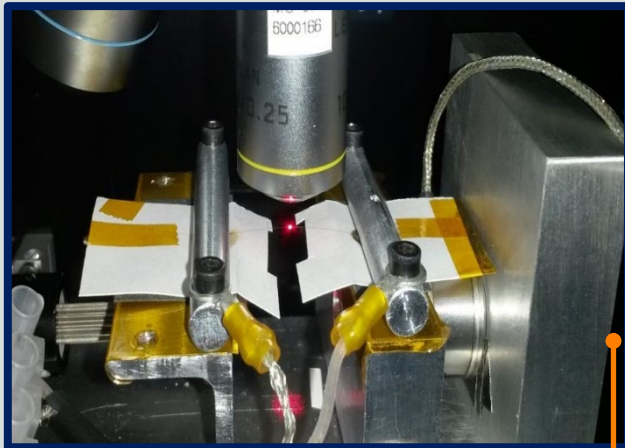
**Electron Beam Welding**



**Material Synthesis**



**Automatic Fiber Placement**



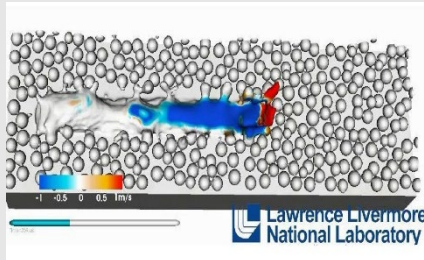
**CNT Fabrication & Characterization**

- Electron Beam Freeform Fabrication with in-situ process control
- Automatic fiber placement with real-time inspection
- Multifunctional CNT fiber composites
- Characterization of optical and electronic transport properties of CNT fibers and graphene depositions

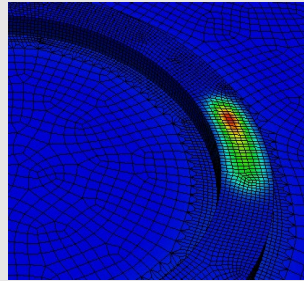


# Computational Materials for Material Processing

## Simulate Fundamental Physics Governing Processing



**Simulation of Laser-Powder  
Bed Interactions**



**Prediction of Local  
Heat Distribution**

- Determine role of processing parameters and composition on microstructure
- Simulate physical processes including laser beam absorption in powder bed, heat transfer via conduction and radiation, and fluid flow at the melt pool, particle flow
- Simulate residual stress, distortion, microstructural evolution and precipitate growth

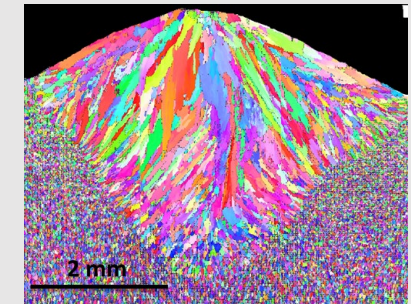
**Develop Physically Correct Models Needed to Support Certification  
of AM Feed Stock and Manufacturing Process**

## Characterize Material Evolution using Experimental Methods

- Employ heavily-instrumented SLM machine and synchrotron beam lines (APS, CHESS)
- Produce coupon-size specimens using well-controlled parameters
- Understand details of the relationship between processing parameters and resulting microstructure



**Selective Laser Melting**



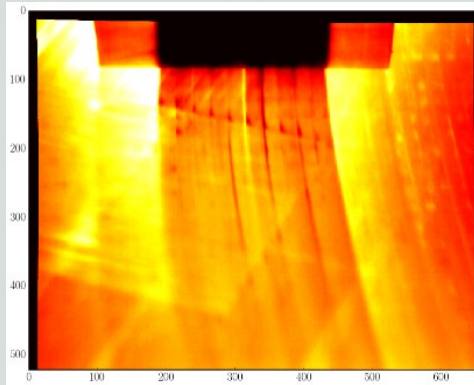
**Grain Structure from  
Additive Process**

# In-situ NDE During Automated Fiber Placement (AFP)

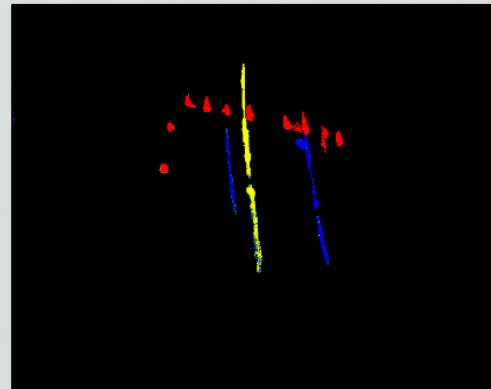
AFP Manufacturing Challenge  
Current Process Time: 19% Layup vs. 42% Inspection  
Goal Process Time: 76% Layup vs. 8% Inspection

## System Capabilities

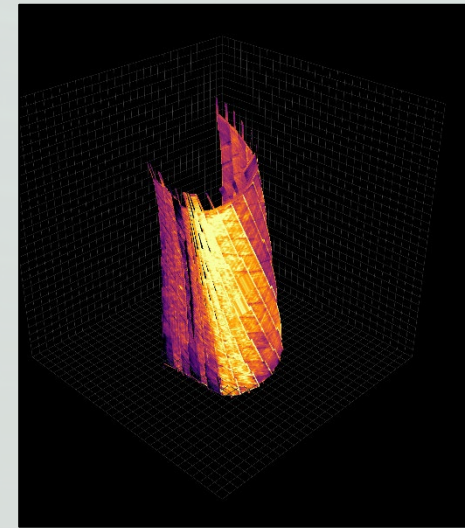
- Real time inspection with immediate defect reporting to operator
- Artificial intelligence algorithms quickly pass pristine data and only highlights discontinuities
- High accuracy/precision of inspection for better risk assessment
- Quantitative measurement of parameters that affect build quality
- Moving toward real time control of the manufacturing process



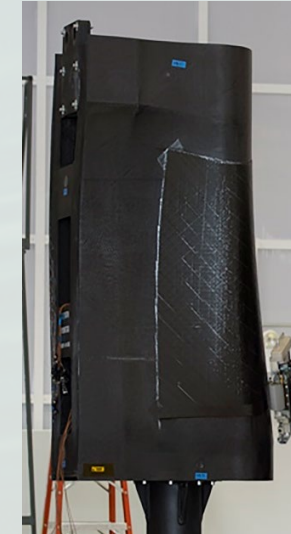
Raw Temperature Data



Automatic Feature Recognition



Temperature Data Mapped  
Layer by Layer



Multi-axis Automated  
Fiber Placement (AFP)  
Robot



# Space Exploration

## Exploration Focus Areas

### Orion and space launch system

Langley provides research and engineering support for the Orion and SLS Programs in the following areas:

- Aerodynamics and aerothermodynamics database development utilizing wind tunnel testing and computational fluid dynamics (CFD)
- Define vehicle controllability requirements and provide independent verification of control laws for Launch Abort Modes and for Crew Module entry
- Heat Shield structures testing and analysis
- Loads & Dynamics
- Payload Fairing and Universal Stage Adapter
- Landing impact dynamics testing and analysis
- Development Flight Instrumentation (DFI)



- Orion Crew Module Heatshield Test at the National Transonic Facility
- Orion Hypersonic Aerothermal Support
- Space Launch System Aerosciences Testing across Langley Wind Tunnels
- Scientifically Calibrated In-Flight Imagery (SCIFLI) Team





# Example Intelligent Flight Systems Contributions to Artemis

National Aeronautics and  
Space Administration



- Human Landing System (HLS) Handling Qualities and Crew Interface Design Assessments
- LaRC Role in Assessment of Lunar Gateway Time-Triggered Ethernet
- Flight Dynamics Research Facilities Provide Vehicle Risk Reduction for Human Exploration
- Orion and SLS Dynamics and Controls



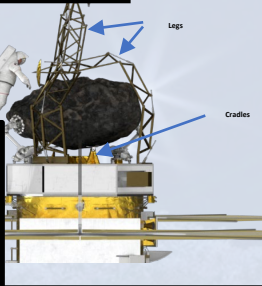
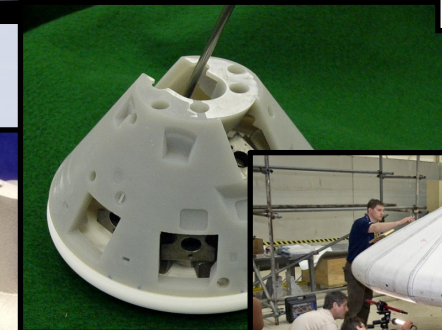
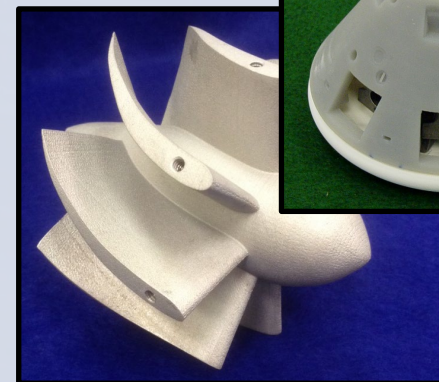
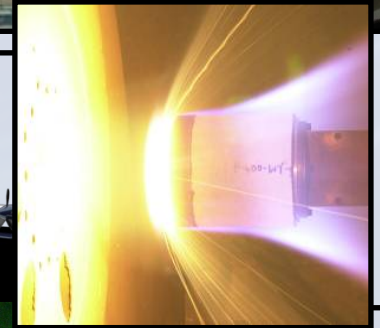
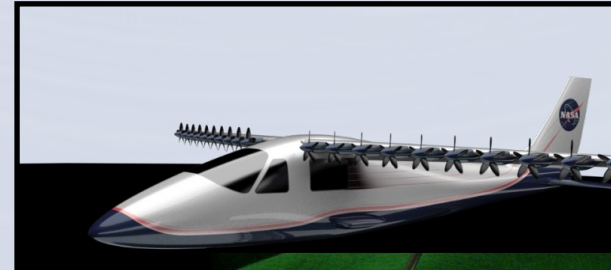
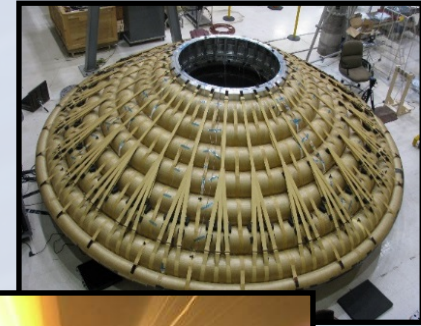
POC: FRANK GERN OR MIKE FREMAUX

# Example Engineering Contributions to Artemis

National Aeronautics and  
Space Administration



- Entry, Descent & Landing and Exploration Systems
- Engineering Design and Development of Flight and Ground-based Systems
- Concept Development and Studies
- Thermal/Structural Design and Analysis
- Verification and Validation
- Real-time, Proof-of-concept hardware for Experimental Applications through Advanced Manufacturing and 3D Printing





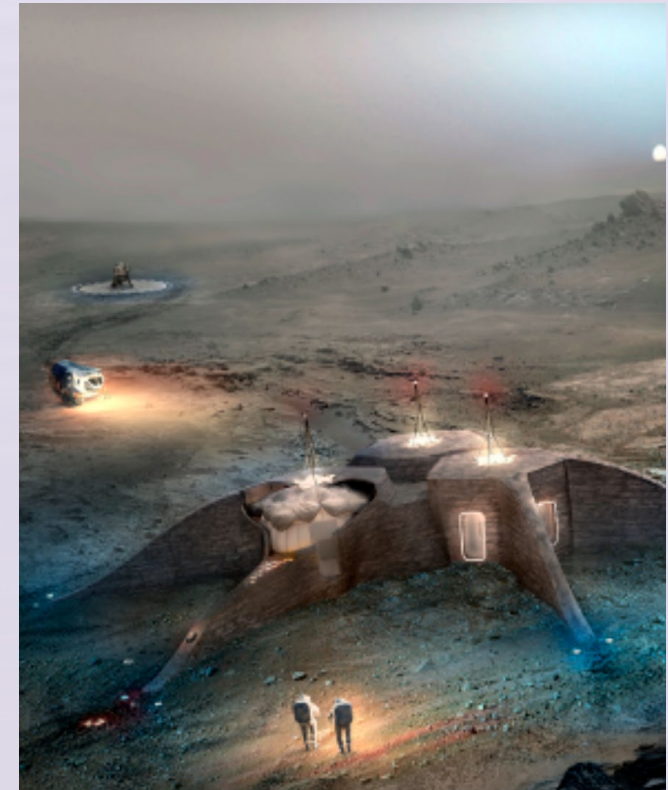
# Space Exploration

## Collaborations

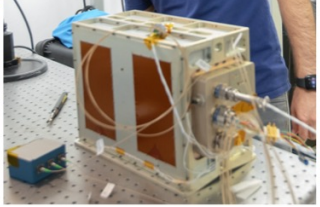
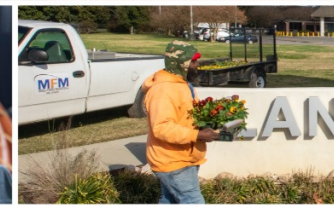
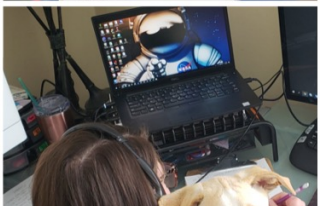
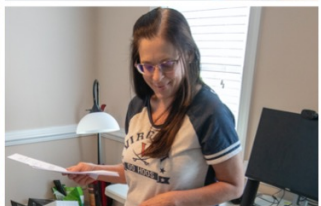
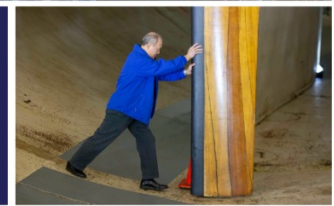
### Work with Langley

For those companies looking to do business or collaborate with us, NASA offers the following opportunities:

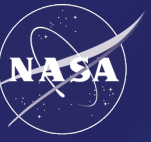
- Directed Work
- Space Act Agreements
- Reimbursable/Non-reimbursable work
- NASA Solicitations (ex. Announcement of Collaboration Opportunity (ACO) and Tipping Point)
- Small Business Innovative Research (SBIR)
- Public-Private Partnerships











Learn more at  
**[www.nasa.gov/langley](http://www.nasa.gov/langley)**



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